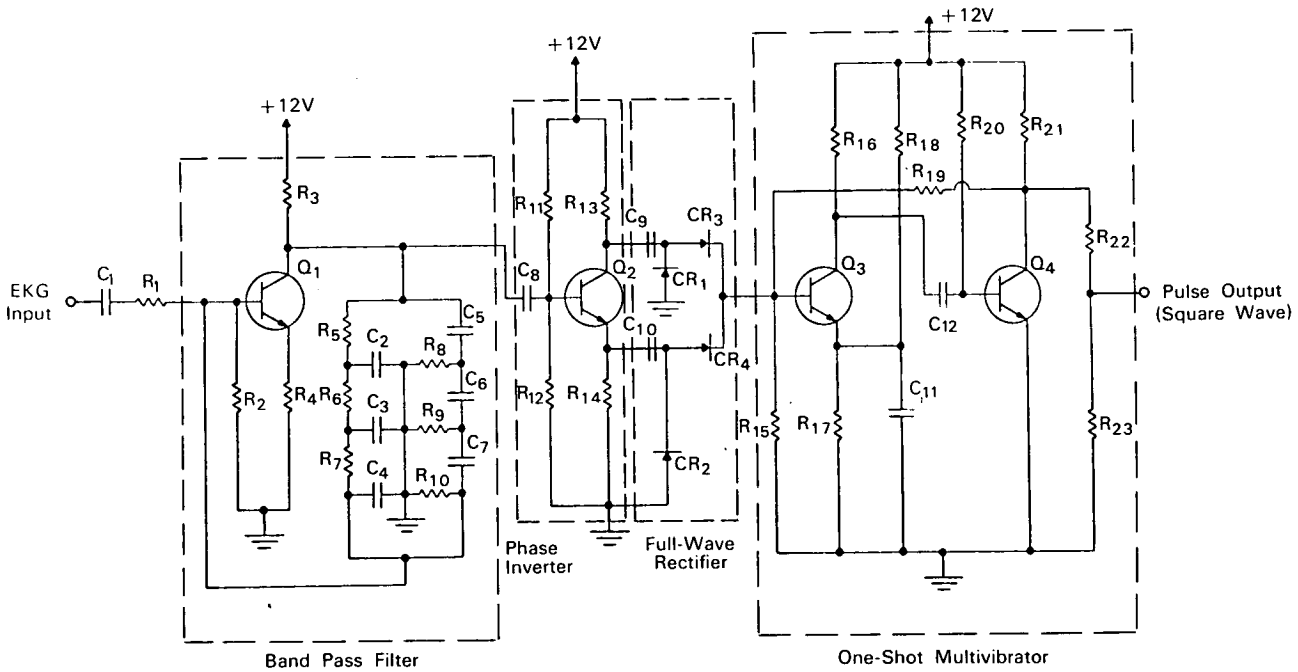
NASA TECH BRIEF

Auxiliary Circuit Enables Automatic Monitoring of EKG's



The problem: Monitoring of electrocardiograms by digital computers. Relatively little difficulty is encountered in analyzing cardiac activity from visual inspection of the QRS waveforms or complex (electrical potential developed by depolarization of the heart ventricles) on an electrocardiogram (EKG) in the presence of interfering signals. These signals can arise from the 60 cps powerlines, the electromyogram (electrical potentials produced by muscular action), baseline changes due to breathing and pickup-electrode movements, unusually large T-waves (which represent the restoration of the polarized state of the ventricles), and changes in magnitude or polarity of the QRS complex. However, both because of the obscuring effect of the noise signals and the analog form of the EKG, the output of conventional electrocardiographs or cardiotachometers cannot be directly monitored by digital computers.

The solution: An auxiliary circuit that produces a noise-free square-wave output signal each time it receives a trigger pulse (R-wave) from an EKG preamplifier.

How it's done: The input signal from an EKG preamplifier is processed through a bandpass filter (which is sharply tuned to the predominant frequency of the QRS complex) to reject extraneous frequency components. The filtered signal is fed into a hybrid full-wave rectifier (one-half of which is fed through a phase inverter), which thus utilizes either positive or

(continued overleaf)

negative initial waveforms to trigger a one-shot multivibrator circuit. The duration of a square-wave pulse from the multivibrator is adjusted to 300 milliseconds to eliminate all extraneous trigger sources and allow for heart rates up to 200 beats per minute.

Capacitor C_1 and resistor R_1 form a dc blocking and matching unit between the EKG preamplifier and the active filter consisting of transistor Q_1 and the filter network R_5 through R_{10} and C_2 through C_7. The filter circuit provides positive feedback at the resonant frequency and negative feedback at frequencies above or below the resonant frequency. Transistor Q_2, dc-biased by R_{11} and R_{12}, acts as a phase inverter which feeds into a hybrid voltage-doubling, full-wave rectifier. Resistor R_{17} and capacitor C_{11} eliminate triggering by transients of the one-shot multivibrator, Q_3-Q_4. The trigger amplitude is determined by the voltage divider R_{17}-R_{18}. The square-wave output pulse, which has a time duration determined by C_{12} and R_{20}, is obtained from the divider network consisting of R_{22} and R_{23}. This output pulse can be fed directly into a magnetic tape recorder, strip chart recorder, or digitizing circuitry for computer programing.

Notes:

1. The output pulse from this circuit can also be used for locating the time of occurence of the QRS complex in relation to an intra-arterial blood-pressure tracing.
2. This circuit should be useful for accurate automatic processing of large amounts of cardiovascular data (EKG and intra-arterial blood pressure) from analog tapes.
3. A circuit that converts the output from this auxiliary circuit into pulses which can be applied to a direct-reading digital voltmeter is described in NASA Tech Brief B65-10143, May 1965.
4. A cardiotachometer which provides an analog indication of average heart rate is described in NASA Tech Brief B65-10010, January 1965.
5. Inquiries concerning this invention and those cited above may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B65-10142

Patent status: NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Texas Institute for Rehabilitation and Research
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